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SCIENCE AND LIFE[1]

By Professor GRAHAM LUSK

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THE explorers of the heavens tell us they have located a galaxy of stars, the light of which, transmitted at the rate of 186,000 miles a second, has been traveling through space for a period of 140 million years before becoming visible to the eye. We may perhaps be pardoned if we take account of the position of some other things which are a little nearer to us. For example, the position of metabolism research has lately been defined by a friend of mine who told me that it was now so far advanced in this country that it needed no further support. It seemed to me to be regrettable that such opinions could be held anywhere. I mentioned this statement to my friend, Karl Thomas, of Leipzig, a former pupil of Rubner, and he comforted me by saying, "Why, the whole of life is metabolism."

[1] Delivered before the Piersol Anatomical Society, the University of Pennsylvania, Philadelphia, February 28, 1930.

A celebrated clinician once elaborated and published a wonderful interlocking endocrinological scheme regarding diabetes. About one out of four of his guesses was right; the other three are now in the receptacle devoted to scientific rubbish. And we witness year after year false interpretations of physical phenomena, because a younger generation has arisen which does not know and apparently does not care to know what the old masters knew of the phenomena of metabolism. It is too much trouble to learn about it. The younger generation wishes to do a few metabolism experiments of its own and to draw conclusions without any knowledge of the background of accumulated evidence which may render the conclusions invalid.

Rubner, during the war, lamented the clamor of those Germans who demanded the production of a super-bread, for he knew of work done fifty years before, which even educated physicians had forgotten,

which precluded the possibility of producing a super-bread.

I would like to dwell for a short time upon the life of Liebig,[2] whose activities were largely responsible for the development of modern metabolism research, as founded in large measure by his pupil, Carl Voit. For the lessons of Liebig's life ~~seem likely to be~~ forgotten in the standardization and mechanized control exercised over American education to-day. So if you will bear with me, we will look backward a hundred years and more.

In 1803 Liebig was born in Darmstadt. He was one of seven children. His father sold oils, paints and dyes. When he was fourteen years old his school teacher complained of his inattention and asked what he would ever become. Liebig replied that he would become a chemist. The laughter which followed this remark caused him to leave school. He sought apprenticeship to an apothecary in the neighboring town of Heppenheim. He learned all he could learn in that environment in ten months and, on returning home, indicated to his father improvements which he could make in his business. At the age of seventeen he went to the University of Bonn to be under Kastner, then the most celebrated chemist in Germany, and he followed Kastner to Erlangen when the latter moved thither.

In a letter written to his parents from Bonn he says:

> I take great pleasure in my studies. The more I understand, the greater my satisfaction. I have begun to realize how little I know, and how much I must learn before I can say, I know something. Please do not forget to send me money.

His typical father writes him from Darmstadt, "Give thyself trouble to learn thoroughly, and practice diligently Latin and French."

And the typical son again, "The most necessary Christmas present which you, my dear parents, can give me, what can it be other than money."

Kastner proved inadequate for the aspiring young student. Liebig has told how Kastner related to the class that the moon had an effect on the clouds, because the moon became visible when the clouds dissolved. But Kastner had the wisdom to recommend this brilliant young man to the Grand Duke of Hesse-Darmstadt and to advise that money be provided so that he could study in Paris. We would to-day call this a traveling fellowship. Through the finance minister, Schleiermacher, Liebig was given a modest sum for his expenses. He traveled to Paris by stage coach at the age of nineteen. At first the small-town lad has a confused impression of the delirious life of a great city, but he writes to Schleiermacher:

> In no other country do the sciences develop so wonderfully as here and this is because of the highly developed mathematical sense of the French scientists, which causes them to reject all useless hypotheses. Gay-Lussac handles the subject of chemistry in a way which shows his complete mastery of it, and Thénard does the same. Experiments are made with lavish expenditure of material. The government spends money freely for such purposes.

Both Thénard and Gay-Lussac had been pupils of Berthollet, who was a pupil of Lavoisier.

Writing more intimately to Walloth, a friend of his own age, he says:

> Behold in me a salutary metamorphosis! The lectures of Gay-Lussac and Thénard have transformed science from an old nag that one has only to saddle in order to ride into a horse with wings which is always trying to escape and which I am constantly trying to capture. I thought I worked in Darmstadt, but here my daily song extends from seven in the morning until midnight and I have pleasure in it. Paris is now much more agreeable to me. Days pass like hours at home . . . and I look sorrowfully forward to the time when I must leave it.

A little later, in a letter to his parents he tells how he has made an interesting discovery. An acid arises from the action of nitric acid on alcohol, and this acid unites with metal oxides to form the fulminates of mercury and of silver. He discovers similar salts of copper, iron and zinc which indicate the exact composition of the substance. The French have been puzzled by these things for a long time. His thesis has been written, Thénard and he review it together and then they walk to the Académie des Sciences. Since Thénard is president of the Académie, he is unable to read the paper, so Gay-Lussac reads it. Liebig brings with him the newly prepared salts and presents them before the Académie. In spite of the rather long thesis there are interruptions of applause. Gay-Lussac and Dulong append their signatures to the following memorandum incorporated in the minutes of the Académie: "Because of the new experiments described in this very remarkable piece of work, we entertain the highest hopes concerning the talents of the author."

After the reading Alexander von Humboldt, the celebrated traveler, who has just returned from Italy after long absence from Paris, a man about fifty-five years of age, approaches the young man and, without revealing his identity, talks with him for nearly an hour and then invites him to dine with him at a restaurant in the Palais Royal, where he tells him who he is.

[2] The author is especially indebted to his friend, Dr. Margaret B. Wilson, for the source of material contained in "Briefe von Justus Liebig nach neuen Funden," 1928, sold at the Liebig Museum at Giessen; and to Pettenkofer's well-known "Gedächtnissrede des Dr. Justus Freiherr von Liebig" (M. von Pettenkofer, "Populäre Vorträge," Braunschweig, 1876, No. III) delivered in 1874, a few months after Liebig's death.

The outcome of this adventure is that Alexander von Humboldt persuades Gay-Lussac to take Liebig into his laboratory where he can receive direct instruction from the greatest of living chemists. At that time Gay-Lussac refused to receive young men. But Humboldt knew from personal experience what it meant to work with Gay-Lussac; they had analyzed atmospheric air together in 1804. Liebig related to Pettenkofer that when Gay-Lussac and he discovered an especially beautiful fact or accomplished successfully an especially difficult analysis, they danced around a table together, the boy of twenty and the older boy of forty-five.

While residing in Paris Liebig received his doctorate degree in 1822 from the University of Erlangen because of two years of work under Kastner. The thesis was on the subject of the fulminate of silver. In it the errors of others were exposed and his own views were clearly expressed in a style of which he was to become a master.

At the close of Liebig's period of education in Paris, Alexander von Humboldt wrote concerning him to Liebig's patron, the Grand Duke Ludwig, as follows:

> We are fortunate in having with us in Paris one of your subjects, whose superior talents, whose vast knowledge of chemistry and whose sagacity of spirit have attracted the lively interest of the Institute of France. Dr. Liebig unites these qualities with gentleness of character and grace of manner, most unusual among scientists of his age. If my feeble voice carries any weight with your Royal Highness, I beg you to continue your special protection of Monsieur Liebig. He will become a professor who will honor our country, and I am positive that profound gratitude, which will also be shared by my colleagues in the Academy, Gay-Lussac, Thénard, Dulong and Vauquelin, will be extended toward a sovereign who will deign to honor one so especially talented.

Through the influence of this letter Liebig, at the age of twenty-one, was appointed professor of chemistry at the University of Giessen without consultation with any members of the faculty. His laboratory was first established in an old military barracks. It is needless to say that the young professor received very little support from his colleagues.

Writing to Schleiermacher to thank him for a small contribution from state funds toward fitting up living quarters above his laboratory, he says:

> The desire always to retain your regard and good-will prevented me from doing many things in Paris which would now disturb my peace of mind, and was a constant stimulus to try to understand and to investigate the branch of science which I had chosen as a calling. Besides this I have you to thank for the opportunity, on account of which I am fortunately able to make the knowledge then acquired live, and to make it useful for the Vaterland. I have to-day received renewed proof of your truly fatherly benevolence. . . . It makes me sad to think that I have not the skill to express my thanks otherwise than in words. Do not disdain these thanks which come from an agitated and honest heart. It will always be my earnest endeavor to preserve your satisfaction with me.

Liebig had a clear idea in mind, that he would personally instruct other young men in chemistry after the manner that Gay-Lussac had instructed him. He first gave his pupils ideas to work out, and then, when they could think for themselves, stimulated them to do so.

German biographers state that before Liebig the German professors generally adopted the attitude that they were not to unbend to the students and tell them their best thoughts. This was along the lines of Goethe when Mephistopheles says to Faust:

> Das Beste, was du wissen kannst,
> Darfst du den Buben doch nicht sagen.

Liebig reversed this and said, "All that I can do I will make the pupils learn also."

Students flocked to Giessen from Germany and then from all parts of the world, as many as twenty at a time being received. All the dialects of Germany and all foreign tongues were to be heard in the laboratory. Each student felt that he was living a life lofty in purpose, that he was serving science, that he was a pupil of Liebig!

The first part of Liebig's program was the establishment of accurate methods of analysis of organic compounds, methods in vogue to-day after a hundred years. He discovered the dibasic organic acids; he discovered chloral and named it; he made aldehyde from alcohol. He called it "aldehyde" because it was alcohol dehydrogenated. The name created laughter. He could have called it Gay-Lussacin without disturbing the then existing scientific world (Pettenkofer). Liebig, with his devoted friend Wöhler, discovered that benzol was just as constant in many different chemical compounds as arsenic was in the inorganic world. Berzelius was so happy over this that he suggested the name *Proin* for the new radical after a Greek word meaning "the dawn of day." Leibig's publications numbered two hundred on the most varied subjects. Their exceptional quality make the number astounding (Pettenkofer).

Liebig, who had been creating the science of organic chemistry, of which he was the supreme exponent, published in 1840 a volume entitled "Organic Chemistry, Its Application to Plant Physiology and to Agriculture," and then in 1842 appeared his celebrated "Animal Chemistry, or Organic Chemistry Applied to Physiology and Pathology." The wide sweep of his intellectual attainments led the way into such different fields as modern biological chemistry and the modern dye industry.

To read our daily newspapers one might conclude that the dye industry created organic chemistry. To believe that would lead to the conclusion that the steel industry created inorganic chemistry. Liebig himself has pointed out that such conceptions belong to the uneducated mind of the masses and that placing dyes on wool does not belong in the same category as the mastery of chemical research.

The growing world influence of Liebig stimulated one Samuel W. Johnson, the son of a Connecticut farmer. Young Johnson wrote his father in 1849:

When I behold myself outstripped by others simply because they have the means, I am strongly tempted to repine at the partiality of fortune, but when I read of the achievements of Davy, Faraday, Klaproth, Liebig, Berzelius and a host of others who have elevated themselves from poverty to the highest stations and shed a halo of glory upon their own names and the age that has produced them by their zealous self-denying struggles after truth, how am I encouraged to tread cheerfully the path of science, though alone and exposed to the sneers of the vulgar and the ignorant. . . . Affectionately the same old sixpence, S. W. JOHNSON.

Johnson was then nineteen years old and was teaching school at Flushing, Long Island. Finally, after five years of testing the son, the father gave him in cash the equivalent of what he had given his other children in farm lands, animals, houses and barns. Thus Johnson was enabled to go abroad when he was twenty-three years old, to study with Liebig and to bring home with him those ideas which established first the Connecticut Agricultural Station and later its counterparts throughout the Union.

It is curious to record that in 1849, the same year that Johnson wrote so appealingly to his father, Liebig wrote that if the revolutionary tendencies of the time brought a blood bath at Giessen, they would go to America and found a German university there. These were the days which drove Carl Schurz and Abraham Jacobi to the United States.

Liebig believed with Lessing that talent consisted essentially of work and will power. The industry within his laboratory was prodigious. Liebig was a rare example of one who knew from boyhood what he wished to do. Addressing Thénard in 1841, he says he had had no other introduction to him in Paris except his love of study and his fixed desire to profit by his teachings. His associate, Pettenkofer, says that Liebig's power lay in the nature of his being, in attributes which no man can acquire but which are inborn. He had endurance, diligence and good methods. He had a sharp penetrating understanding coupled with a restless, active imagination (without being in the least a dreamer). These attributes were intimately and harmoniously blended. Mental concentration on concrete problems played the greatest part in the scientific achievements of his life. Liebig himself has told us that the quiet and the freedom from interruptions in the small town of Giessen enabled him to accomplish what it would have been impossible to do in a large city. However, his work at Giessen became so arduous, he tells us, that constant ill-health embittered his life. After his removal to Munich in 1853 his health improved, he could eat and sleep like other men, which had not been true for many years. He took no more students into his laboratory, and the glory of his life was in the past, in the twenty-eight years spent at Giessen. Others were carrying out his methods in a manner which made Germany supreme in chemical knowledge.

On his sixtieth birthday he makes a memorandum that his reception in Paris bordered on the miraculous. He says he has observed that when any one possesses a pronounced talent this awakens in all men an irresistible desire to contribute to its development. All help, as though they had counseled together to do so. But talent can be successful only when it is united with a definite constancy of purpose. Unfavorable external obstacles to the development of talent are small in comparison with those which lie in the man himself; for just as a natural force, be it ever so powerful, is ineffective in itself unless reacting with other forces, so a man who learns without trouble, one who has inherited definite intellectual gifts and preferences, can succeed only after he has learned a great many other things at the cost of greater effort than other people may have to make to acquire the same knowledge. For that reason he agrees with Lessing that talent is work and will.

A German biographer, quoting Shakespeare, says of him:

His life was gentle; and the elements
So mix'd in him, that Nature might stand up,
And say to all the world, *This was a man!*

The story of Liebig's life carries its lesson to us to-day. American philanthropy is building great buildings for education, greater buildings than the world has ever seen. Those who visited this country last summer in connection with the XIII International Physiological Congress marveled at them and at their equipment and went home and wrote about it. We are building great comfortable homes for the students in our colleges; we are planning pent-house apartments for the internes in our hospitals. But who is concerned with the material welfare of the professor? The answer is, virtually no one. No penthouse apartments are thought of for him. And what are we doing to pick out the exceptional young man and develop him? To this question it may be stated

that the National Research Fellowships initiated by the Rockefeller Foundation on the advice of the former professor of experimental medicine at the University of Pennsylvania, Dr. Richard M. Pearce, have done a vast amount of good (written the day before Dr. Pearce's death). It is said that privately endowed universities can not undertake this task. However, we might also welcome a return to the older method of the personal touch of Alexander von Humboldt, which magnified Liebig's opportunities, of the personal interest in him of the Grand Duke, and of the "truly fatherly benevolence" of Schleiermacher. The supporting influence of these three enabled a brilliant young man to shed undying glory on his country.

For the most part this personal touch is lacking in this America of ours. Money is given, and that is thought to suffice. The money is devoured by buildings and then by the routine necessities of running them. But support should be given to the education of brilliant young men who will work, support which follows through to the end. Work is the surest criterion. If a young laboratory man, be he ever so brilliant, spends his time at his desk at best indulging in philosophic thought, it is wise to get rid of him entirely, perhaps through removal into another environment which incites him to work. It is easy enough to distinguish between the workers and the drones. It is easy enough to distinguish between brilliancy and stupidity. But there is very inadequate machinery to give exceptional education to the brilliant worker. Not only this, but one should also remember that the most highly gifted professors, unless they have private means, lead lives of self-inflicted poverty.

It was believed at Yale at the time of Liebig that chemistry, like virtue, should be its own reward.

At the present time we should be alert to the fact that our over-organized university machinery is not producing as many real scientific men of the highest intellectual caliber as our material resources, if not our national pride, justify. German universities have always been able to fall back upon state funds when aid is needed, because the universities there are considered to be a part of the glory of the state itself. This attitude is too little appreciated in our own country.

The modern furor about changes in the curriculum matters little. The most important fact is that the student, before he begins to think, must have something to think about. And this involves learning not only what he likes and what is easily acquired, but also, according to Liebig, a great deal that he does not like at the expense of his will power.

Carl Voit was a physiologist with a physician's training, and he was able to give more of a physiological interpretation to the problems of metabolism than was Liebig. Pettenkofer and Voit built the first respiration apparatus for the determination of metabolism in man. Voit determined the metabolism in human diabetes and in leukemia as early as 1866. He always taught that one case carefully examined gave more information than the statistical array of hundreds.

In our own country metabolism work has been carried on largely as an extension of the German background. F. G. Benedict, Boothby, DuBois and I have been greatly interested in the subject. Recently, Richardson, Loebel and Shorr have been using the Warburg apparatus for the determination of the metabolism of thin slices of living isolated tissue. Just as in the case of a man placed in the respiratory calorimeter, the respiratory quotients of the isolated tissue vary with the food provided in the surrounding medium. When glucose is added to the medium, the respiratory quotient and the intensity of oxidation both rise, thus manifesting the phenomenon of the specific dynamic action of burning carbohydrate just as it occurs in man.

Recently these same authors have been investigating the respiratory phenomena of the tubercle bacillus. DuBois said the other day that he could map out a ten-year program for work along these lines.

So it becomes apparent that each generation of workers approaches a clearer appreciation of the phenomena of metabolism. It is far from complete. It is only through joyous work that it will be carried on, through work so rewarding that it would make one feel like dancing around a table, just as Gay-Lussac and Liebig did. It will be finished only when a knowledge of life itself is complete.

Sir James Jeans, in his recent book, "The Universe around Us," says that if one takes the height of a large Egyptian obelisk as the measurement of the time since the birth of the earth out of the mass of the sun, then the life of man on the earth would be represented by a penny on the top of the obelisk, and the time during which man has been civilized, or 5,000 years, would be represented by the thickness of a postage stamp. He estimates man's probable future in terms of additional time to exceed the height of Mont Blanc put on top of the penny and adds:

> As inhabitants of the earth we are living at the very beginning of time. We have come into being at the fresh glory of the dawn and a day of almost unthinkable length stretches before us with unimaginable opportunities for accomplishment. Our descendants in far-off ages, looking down this long vista of time from the other end, will see our present age as the misty morning of the world's history. . . . By what light we have, we seem to discern that the main message . . . is one of hope to the race and of responsibility to the individual—of responsibility because we are drawing plans and laying foundations for a longer future than we can well imagine.

THE RELATIONSHIP BETWEEN SCIENCE AND ENGINEERING[1]

By Dr. GANO DUNN
NEW YORK, N. Y.

SCIENCE has worked so many miracles and stands so high in popular esteem that her name is borrowed to dress up all sorts of causes that want to make a favorable impression. In consequence of this there is confusion as to the meaning of the term. We even hear of the science of pugilism.

A similar broadening and thinning has occurred in the term engineering, of which there have already developed over fifty varieties, one of which is called human engineering.

Notwithstanding all the pulling and hauling which each term has had to undergo in the struggle of new ideas and developments to attract public favor, in this heyday of the scientist and of the engineer when their fields often merge or overlap, there is a fundamental distinction between them, which, however, is not incompatible with the closest of relationships.

What is this fundamental distinction?

Science is a method of arriving at knowledge, and it is also the body of knowledge arrived at. The dictionary calls it an ordered knowledge of natural phenomena and the relation between them. It has also been called that process of reasoning based upon observed data and working hypothesis which by inductive and deductive procedure and experiment leads to new knowledge.

There has been a constant growth in the conception of what science is from the time when it was called natural philosophy down to the present when its field includes practically everything that can be considered objectively.

Science is as ancient as the classics and is in fact part of the classics notwithstanding the antithesis that is sometimes set up between the two as representing opposite poles of programs of education.

Modern science began with Galileo. He founded it not so much by the great discoveries he made as by the way he made them. There is no scientist to-day who does not consciously or unconsciously follow in that great Italian's footsteps, footsteps that go over the ground of observation, hypothesis, deduction and confirmatory experiment.

By shutting the mind as far as possible to all human prejudice and influence of feeling, save only the divine fire of imagination which creates the working hypothesis, science learns to discern in the order of nature paradoxes that are found to be truths, and new knowledge that is revolutionary.

Between the pebble and the mountain, between the worm and the man, science sees the superficial difference and the profound resemblance. Nothing is so insignificant as to be foreign to her scope. Her generalizations are in turn regeneralized, until, looking back upon her path, we acquire some measure of what her future may be.

They are no idle boasts, those legends written under the dome of the beautiful temple of science in Washington, "Pilot of Industry," "Conqueror of Disease," "Multiplier of the Harvest," "Explorer of the Universe," "Revealer of Nature's Laws," "Eternal Guide to Truth."

The priests who sacrifice in her temple know the joys of the freedom of the human intellect, and those who pity their sometimes apparent isolation from the world themselves are to be pitied for their own exclusion from the scientist's ecstasy of thought.

But beside her priests science has her worshipers who go out into the world and are a part of it. They are the engineers.

Engineering is the art of the economic application of science to the purposes of man. Of this definition every term is pregnant.

Science in the sense of a body of knowledge was applied to the purposes of man when our prehistoric progenitor first jumped upon a log to float across a river instead of swimming, but for several reasons that was not what we now mean by engineering.

In Egypt, Greece and Rome, as in middle age China and elsewhere in the world, we have great engineering works, but the relation of these to the scientific knowledge of their day, while of absorbing interest, was on a different basis from that which underlies the present economic age we live in.

Engineering as we know it is a new profession, born about 1750, the child of the industrial era. As industries have grown and diversified with the progress of science, the present vast field of the engineer has been created.

We do not call the first man to do a thing an engineer because he invented it. It is only when he begins to do it over and over again for the purposes of man that he earns this designation. While the terms inventor and engineer often describe the same man, it is because he combines both functions.

He is an engineer when he applies science as an art. An art is something to be done rather than something to be thought. It involves constant repeti-

[1] Address given before the Alumni of Columbia University on February 12.

tion. It implies skill gained in repetition. It implies improvement and it implies style.

But of the many kinds of art, fine arts and useful arts, the engineer deals only with those that are useful. Utility is the standard by which his function stands or falls.

And how is utility measured? It is measured by the economic test. In this hot crucible of the economic test all his works are tried. He is an engineer only when he can do with one dollar what any fool can do with two.

It is because his art deals with dollars and economic relations that he is bound into the great business structure of society, and being bound into this structure he must be a man among men. He must be able to make his views prevail, to persuade, to contend, to give blows and to take them.

The scholar in his closet or the scientist in his laboratory does not do these things. To the engineer they are every-day life.

And if his training neglects the great human mirrors of history and languages, particularly his own language, if his mind and his heart are insensible to the great social forces, if he but feebly develops the subtle qualities of character that make for personality, his career as an engineer is limited, no matter how much science he knows.

The realm of economics where he works is a human realm involving organization, leadership and sympathy, to say nothing of passion, ignorance and vanity. Value is its criterion rather than truth.

The business of the engineer is no business for the philosopher. To be trusted with the expenditure of other people's money is no calling for a dreamer. If the key to the scientist is thought, the key to the engineer is action.

Engineering is not related to all of science.

As a body of knowledge science is composed of many sciences. Their practical application gives rise to many arts not all of which are economic or practiced by the engineer.

The science of biology has its art of medicine. The science of anatomy has its art of surgery. The science of astronomy has its art of navigation. The sciences of mathematics, mechanics, physics and chemistry have their art of engineering, which is the art of the economic application of these sciences to the purposes of man.

THE WOODS HOLE OCEANOGRAPHIC INSTITUTION

By Dr. HENRY B. BIGELOW

DIRECTOR

IT is gratifying to report that the study of the present status of oceanography made by the committee of the National Academy on that subject and their recommendations[1] have borne fruit in the incorporation of a new establishment for the study of the sea, the Woods Hole Oceanographic Institution. And it is still more encouraging to students in sea science that the Rockefeller Foundation has appropriated for the new institution funds sufficient to assure it an adequate building program and sufficient operating income.

The purpose of the new institution, as its name implies, is to carry on and to encourage the study of the sea in the broadest sense. Like the Marine Biological Laboratory, it is an independent organization, but similarly assured of informal association with other educational and research institutions through the personnel of its trustees. The initial board is as follows: Dr. Thomas Barbour, Dr. Henry B. Bigelow (director), Dr. William Bowie, Dr. E. G. Conklin, Mr. Newcomb Carlton, Dr. Benjamin M. Duggar, Dr. Frank R. Lillie (president), Dr. John C. Merriam, Mr. Seward D. Prosser, Mr. Lawrason Riggs, Jr. (treasurer), Mr. Elihu Root, Jr., Dr. Harlow Shapley, Dr. T. Wayland Vaughan. The by-laws provide for an increase in the number of trustees up to twenty-four.

The choice of Woods Hole as the site for the headquarters of the new institution was reached only after a careful consideration of other possible situations along the Atlantic Coast of North America. The final decision was based on the combined advantage of close proximity to two world-famed laboratories of marine biology, on the one hand, and, on the other, on the exceptional opportunity for illustrative investigations that is offered by the neighboring waters.

The first of these inducements needs no explanation. The second depends in part upon the ease with which the transition from inshore to offshore waters can be reached from Woods Hole, on the abruptness of that transition and on proximity to the continental slope, and abyss. At the same time the Gulf of Maine, close at hand, with its tributaries, offers a more promising field for intensive investigations into the interaction between the physical-chemical and the biologic aspects of oceanography than any other sector of comparable extent along the coast of America. This follows from the fact that deep troughs, freely open

[1] SCIENCE, 71: 84–89.

to the ocean, enclosed sinks, a varied coast-line, a wide range of depth and offshore banks supporting some of the most productive of sea fisheries can all be reached within a few hours' sail from Woods Hole, while the transition from regions of extreme turbulence to waters more stable can be followed within short distances. The thermal diversity (regional, bathymetric and seasonal) is also wide, with temperatures ranging within a few miles of Woods Hole, and at different seasons, from below the freezing-point of fresh water to values almost tropical. A wide variation in the fertility of the local waters for pelagic plants is reflected by variations in the mass productions of the latter, while the faunal associations (including the planktonic) are equally diverse and abundant.

In short, there is hardly an oceanographic problem but can be hopefully attacked close to Woods Hole, unless primarily associated either with tropical shallows, with Arctic ice or with mid-oceanic conditions. The northeastern coast of the United States with neighboring parts of Canada is the most convenient headquarters for studies in the last two of these fields combined, because of nearness on the one hand to the ice-laden Labrador current (chief discharge of Arctic waters into the Atlantic) and on the other to the open Atlantic basin, with Bermuda in the offing as the possible site of a future substation.

The preceding remarks introduce one of the most important features of the institution's program, namely, that it expects to own and operate a seagoing ship, of moderate size, with convenient living quarters, capable of extended voyages and equipped to carry on investigations at all depths in the various fields of sea science. This is the more desirable because no other American marine laboratory independent of governmental control is at present in condition to do this. To make the most of such facilities, it is planned to keep the laboratory open with resident staff and the ship in commission the year round.

Plans for the laboratory building, docks, etc., are now being prepared and the institution hopes to open its doors by the summer of 1931. Before that time the trustees expect to announce in detail what facilities can be offered and what initial program of research is planned, based on the general purpose of offering every opportunity (compatible with work on shipboard) for participation by visiting oceanographers, whether from America or from abroad. This implies field-investigations in a variety of subjects, for which the offing of Woods Hole is favorable for the reasons just stated. The most essential activities of the institution may be expected to center around the work at sea. In this connection it must, accordingly, be recognized that the technical requirement of oceanography (necessity for obtaining the raw data for the major problems at sea) will confine the projects that can be undertaken at any one time to those that can be provided for simultaneously by the station's fleet. Consequently the activities, not only of the staff but likewise of many of the visitors, must be coordinated parts of a joint program. At the same time the laboratory purposes to offer every hospitality to individual workers who may elect to attack, independently, any problems the data for which can be obtained from the pier or from small boats.

At present few opportunities are open for the student of oceanography to gain experience in the technique of his subject, and the first-hand intimacy with the sea that he requires as a background for his detailed studies. The institution therefore expects to offer to university students instruction in oceanographic methods by participation both in the cruises and in the general work of the laboratory.

To carry out this part of the program, as well as to make the facilities available to qualified investigators, friendly and continuing relations with universities are obviously essential. Equally essential will be a constant endeavor to encourage the coordination of effort between various scientific institutions of this and other countries, that is especially needed in oceanography, where the area to be covered is so vast and where so many fields of science intertwine.

SCIENTIFIC EVENTS

THE DEGREE OF CHEMICAL ENGINEER AT CORNELL UNIVERSITY

IN response to an increasing demand on the part of industry for engineers who have had a specialized training in chemistry, the College of Engineering and the Department of Chemistry of Cornell University have been authorized by the Board of Trustees to offer jointly a curriculum leading to the degree of chemical engineer. This curriculum comprises five years of required and elective work. During the first four of these five years the student who expects ultimately to receive the degree of chemical engineer will be registered in the College of Arts and Sciences as a candidate for the degree of bachelor of chemistry, receiving that degree upon the completion of a definite four-year curriculum, the last two years of which contain a number of fundamental engineering subjects. During the fifth year of residence, the stu-

dent will be registered in the College of Engineering as a candidate for the degree of chemical engineer and will receive that degree upon the satisfactory completion of this additional year of required and elective work.

In commenting on the innovation, Professor C. M. Dennis, head of the department of chemistry, stated that no student will be permitted to register for the degree of chemical engineer who has not completed the requirements for the degree of bachelor of chemistry or the full equivalent thereof, for years of observation and the testimony of alumni in industrial positions have convinced the Department of Chemistry that broad and thorough training in the various fields of chemistry is absolutely indispensable to the full success of the chemical engineer in his professional practice.

Professor Dennis points out further that there is a well-developed demand on the part of the chemical industries not only for graduates in chemistry and chemical engineering, but also for those who hold the degree of doctor of philosophy. "It is our expectation that many of the students who complete the course in chemical engineering will decide to continue for the doctorate, just as do many of those now who graduate as bachelors of chemistry."

Inasmuch as the fifth year of study for the degree of chemical engineer is graduate in character, the graduate school of Cornell University has ruled that this fifth year may be accepted as satisfying one year of the residence requirement for the degree of doctor of philosophy. In summing up the situation which exists in the chemical industry, Professor Dennis stated further:

> The student at Cornell University who wishes to prepare himself for the profession of chemistry may, therefore, receive the degree of bachelor of chemistry at the end of four years, the degree of chemical engineer at the end of a fifth year of study, and the degree of doctor of philosophy upon the completion of two further years of study and research. He may, of course, terminate his university residence at the end of the fourth year, or of the fifth year, or of the seventh year. There is demand in the chemical industries for all three groups of graduates. It should be borne in mind, however, that the training that the student acquires in the fifth year of study for the degree of chemical engineer is of great value for those who seek positions that have to do with the development and supervision of the operation of industrial chemical processes and plants. The advanced work leading to the degree of doctor of philosophy constitutes admirable preparation for responsible industrial positions that involve research or the supervision of research, and many of the larger chemical industries now require that their appointees hold this degree. Most universities and larger colleges also restrict appointments to higher positions on their staffs to those who hold the degree of doctor of philosophy.

GIFT OF THE GUGGENHEIM FOUNDATION TO THE GEORGIA SCHOOL OF TECHNOLOGY

THE committee of trustees appointed by Ambassador Harry F. Guggenheim, president of the Daniel Guggenheim Fund for the Promotion of Aeronautics, has authorized a grant of $300,000 for the establishment of an aeronautical engineering center in the south to the Georgia School of Technology.

Some months ago the trustees of the fund announced that a grant would be made for the establishment of such a center in the southern states to supplement previous grants made by the Daniel Guggenheim Fund for similar schools in other parts of the country. Twenty-seven requests were received by the fund from southern educational institutions, and each of these was investigated by a committee of four of the trustees of the fund appointed by the president.

In addition to personal inspection, a canvass of expert opinion was made among those in a position to judge which institution was best suited to carry out the kind of engineering work contemplated in the fund's plan. As a result of this inspection and investigation, three institutions were found to fill practically all the requirements of the fund, which rendered the final selection very difficult. Geographical location caused the elimination of a number of institutions which were otherwise well suited for the grant.

After much consideration and discussion, and giving due consideration to location, aviation environment, cosmopolitan characteristics of the student body and engineering requirements, in addition to the general requirements of the fund in connection with grants of this character, the committee finally decided to make the grant to the Georgia School of Technology.

This gift brings the total grants by the fund to educational institutions to about $1,500,000, as follows: California Institute of Technology, $350,000; Harvard University Graduate School of Business, $15,000; Massachusetts Institute of Technology, $264,000; Leland Stanford University, $195,000; University of Michigan, $78,000; University of Washington, $290,000; Georgia School of Technology, $300,000.

The award to the Georgia School of Technology is the final act of the fund, which officially ceased to exist on January 31, after having accomplished the purposes for which it was founded in 1926 by Mr. Guggenheim.

GRANTS BY THE COMMITTEE OF THE NATIONAL RESEARCH COUNCIL ON THE EFFECTS OF RADIATION UPON LIVING ORGANISMS

The committee appointed by the division of biology and agriculture of the National Research Council to collect and administer funds for the support of research upon the effects of radiation will complete the second year of its existence on June 30. After the period of solicitation and preliminary organization, as reported in Science, January 4, 1929, the committee found itself able to vote grants totaling over $25,000 for the year beginning July 1, 1929. These were distributed among some twenty-five investigators in amounts varying from $100 to $2,000. In addition to such financial support, the committee has made substantial assignments of apparatus donated by manufacturers, and has introduced individual investigators to the research departments of various industrial establishments for advice and other assistance. Two hundred milligrams of radium have been available as a part of this service and also radium emanations. It is hoped that similar assistance can be continued during the five-year period originally contemplated. In addition to its functions of solicitation and distribution, the committee has plans for a survey of the field of investigations.

As now constituted the personnel of this committee includes the following individuals:

Standing Committee: D. H. Tennent, L. L. Woodruff, W. C. Curtis (*Chairman*).

Sub-committee on Allotment of Grants: C. E. Allen, William Crocker, W. C. Curtis, H. S. Jennings, G. H. Parker, L. L. Woodruff, D. H. Tennent (*Chairman*).

Sub-committee on Survey: A. F. Blakeslee, Janet Howell Clark, Max Ellis, C. S. Gager, F. B. Hanson, E. E. Just, S. O. Mast, H. W. Popp, B. M. Duggar (*Chairman*).

C. E. Allen, *Chairman*
Division of Biology and Agriculture of the National Research Council

THE POSTPONEMENT TO 1931 OF AEROARCTIC'S FIRST EXPEDITION

It is with great regret that the postponement must be announced of the first expedition to the Polar regions of the International Society for the Exploration of the Arctic Regions by Means of Aircraft (Aeroarctic) which had been planned for April and May, 1930, on the *Graf Zeppelin*. Although all financial arrangements as well as the construction, preparation and tests of the necessary scientific apparatus and methods for the extended observational program had been made, it developed about the middle of December that, contrary to its expectations and agreement with Aeroarctic, the Luftschiffbau-Zeppelin Company could not obtain from underwriters insurance covering the ship and crew for the proposed Arctic trip—an obligation which the company had assumed as a part of its original contract with the society for the use of the airship.

The Central Executive Committee of the Society has now taken up independently the question of insurance and, according to latest advices, has received assurance of acceptance by responsible parties of the greater part of the insurance risk. Unfortunately this assurance was received too late to permit forwarding of the great amount of airship supplies and equipment necessary to reach the several base-stations in Norway and at Fairbanks, Alaska, in time for the needs of the ship in April, 1930. The meteorological conditions of the Arctic are unfavorable for the success of the expedition as planned after April and May.

Through the most energetic application of the various scientific and technical commissions of the society, the scientific equipment, methods and constructions had all been remarkably well prepared, involving an expenditure of 350,000 marks, according to the information received from the Central Executive Committee. Thanks to the enthusiastic endeavors of the citizens of Fairbanks through its Commercial Club, the Territorial Government of Alaska and the Alaska Road Commission of the U. S. War Department, an especially well-fitted landing field has been prepared at Fairbanks involving an expenditure of about $12,000, all of which, except for $1,800 supplied by the society, was provided locally.

That the executive committee of the society fully expects to realize in 1931 its carefully laid plans for 1930 is indicated by the following extracts from a letter dated January 20 at Berlin:

> The Executive Committee of Aeroarctic takes this opportunity to request all the national sections to continue to work most energetically for the achievement of the society's purposes. The committee is convinced that the accomplishment of the investigational program is of the greatest economic and scientific importance. It will put forth all its forces to insure that the expedition takes place in April to May, 1931.
>
> Aeroarctic is under special obligation to the governments of Germany, U. S. S. R., Norway, Denmark, Spain, United States and Canada, which have taken such great interest in the practical advancement of the enterprise. The committee accordingly requests the presidents of the national sections to express the thanks of the society to the proper offices of the above-named governments and to request their support of its future plans.

As in all pioneer work such as this, initial delays and disappointments must serve only to spur on its sponsors. The importance of increasing our geophysical knowledge of the Polar regions is so great in every sense that the delay in the realization of the plans of the society will doubtless be compensated for in the greater achievement which must come with any effective realization of these plans in 1931.

JNO. A. FLEMING
Acting Vice-president, American Section, Aeroarctic

WASHINGTON, D. C.
FEBRUARY 28, 1930

SCIENTIFIC NOTES AND NEWS

DR. CHRISTINE LADD-FRANKLIN, lecturer in psychology and logic at Columbia University, died on March 5, in her eighty-third year.

DR. ROBERT W. WOOD, professor of experimental physics and chairman of the department of physics of the Johns Hopkins University, has been elected an honorary member of the Academy of Sciences of Leningrad.

THE Franklin Institute has awarded Franklin medals for the year 1930 to Sir William Bragg, director of the Davy-Faraday Research Laboratory of the Royal Institution of Great Britain, in recognition of his original and valuable contributions to the knowledge of atomic structures and of his inspiring leadership of the Royal Institution; and to Dr. John F. Stevens, because of his solutions of the engineering problems involved in making the plans and effecting the engineering organization for construction of the Panama Canal, and because of his distinguished success in the location, erection and administration of railroads, both in the United States and in foreign lands. The medals will be presented at the annual medal-day exercises of The Franklin Institute, to be held in the hall of the institute in Philadelphia on the afternoon of May 21. Both Sir William and Dr. Stevens will be present to receive their medals and will read papers before the meeting.

THE Brooklyn Polytechnic Institute, which has never given an honorary degree since it was founded seventy-five years ago, will break its custom to confer upon Rear Admiral Richard E. Byrd the title of doctor of science at the annual commencement exercises in June. The people of Virginia will present a sword of honor to Rear Admiral Byrd under a resolution passed by the General Assembly.

THE George Montefiore prize for the year 1929 has been awarded to R. D. Evans and C. F. Wagner, Westinghouse engineers, in conjunction with three other engineers—Algeri Marino, of Rome, and H. Parodi and Pestarine, of Paris. This triennial prize presented by the Fondation George Montefiore of Liége, Belgium, for the best original work contributing to scientific advancement in the technical applications of electricity was given to Messrs. Evans and Wagner for their papers on "Studies of Transmission Stability" and "Static Stability Limits and the Intermediate Condenser Station." The amount awarded to Messrs. Evans and Wagner was 3,000 Belgian francs. The two previous Montefiore prizes of 1925 and 1922 were awarded to Dr. J. B. Whitehead, professor of electrical engineering and dean of the faculty of engineering of the Johns Hopkins University, for his papers on "Gaseous Ionization in Built-up Insulation" and "The Corona Voltmeter and the Electric Strength of Air."

THE Colorado Engineering Council on January 23 presented its gold medal of award to A. J. Weinig for meritorious engineering service in the field of metallurgy, "in recognition of his valuable services to the mining industry of Colorado and the whole nation, for his application of the theoretical to the practical in metallurgical practices and for his contributions to improvements in the flotation method of concentrating ores."

SIR ALFRED YARROW has been elected an honorary member of the British Institution of Civil Engineers.

GEORGE STUART GORDON, president of Magdalen College and honorary fellow of Merton College, Oxford; Professor Owen Willans Richardson, director of research in physics, King's College, London; Mr. Henry Thomas Tizard, rector of the Imperial College of Science and Technology, have been elected members of the Athenæum Club, under the provision which empowers the annual election by the committee of a certain number of persons of distinguished eminence in science, literature or the arts, or for public service.

DR. A. C. D. CROMMELIN has been elected president of the Royal Astronomical Society, London.

DR. WILLIAM H. ROBEY, clinical professor of medicine at the Harvard Medical School, has been reelected president of the American Heart Association. He is also president of the New England Heart Association.

AT Harvard University Dr. L. W. Collett has resigned the professorship of geology which he has

held since 1928; Dr. George Bogdan Kistiakowsky, of Princeton University, has become assistant professor of chemistry.

Dr. Charles W. M. Poynter, who has been acting dean of the University of Nebraska College of Medicine, Omaha, since September 1, 1929, has been made dean of the college and superintendent of the medical college hospital. He joined the university faculty in 1905 as professor of anatomy.

Dr. T. J. J. See, who, as a captain in the navy, has been in charge of the naval chronometer and time station at Mare Island, California, for the past twenty-seven years, has retired from active service, having reached the statutory age of sixty-four years.

We learn from *Nature* that the Medical Research Council has appointed Air Vice-marshal David Munro, on his retirement as director of medical services, Royal Air Force, to be secretary of the Industrial Health Research Board in succession to Mr. D. R. Wilson, lately appointed deputy chief inspector of factories at the Home Office.

Dr. Gustav Klein, who, as successor to Professor Molisch at the University of Vienna, holds the chair of plant physiology, has been asked by the I. G. Farben-Industrie in Ludwigshafen, manufacturers of chemicals, to take over the direction of its newly created cancer institute, which is said to be the largest in Europe. His special field will be researches on the etiology of cancer.

Dr. C. B. Jolliffe, of the Bureau of Standards, on March 1 took office as chief engineer of the Federal Radio Commission.

Robert P. Herwick, assistant in pharmacology in the University of Wisconsin, has been appointed acting state toxicologist, to succeed Dr. Clarence W. Muehlberger, who is joining the Scientific Crime Detection Laboratory at Northwestern University.

Dr. Louis Cohen has been appointed superintendent of the Otisville Sanitarium, Otisville, New York, the New York City tuberculosis institution.

W. H. Monsson, chemist on the pulp and paper staff at the U. S. Forest Products Laboratory at Madison, Wisconsin, has left the laboratory to join the Munising Paper Company.

Dr. Ira L. Kaplan has been appointed director of the New York City Cancer Institute, to succeed Dr. Isaac Levin, in a general reorganization of the medical board of the institute. The post of assistant director, newly created, was filled by Dr. Robert P. Wadhams, a colonel in the medical unit of the National Guard. He also is a teacher at the New York University Medical School and a visiting surgeon at Bellevue Hospital.

After visiting most of the countries of Central Europe and working their way well into Asia, H. L. Westover and W. E. Whitehouse, plant explorers of the Bureau of Plant Industry, have returned to the United States, bringing several hundred new plant varieties, principally alfalfa and fruits.

Professor Samuel J. Holmes, of the department of zoology of the University of California, who is now spending his sabbatical year studying in Europe, recently lectured by special invitation before the Eugenics Society of England, at the Royal Society headquarters in London. The subject of his lecture was "Family Resemblances in Mental Traits and the Weakness of the Environmental Explanation."

Dr. Carl Størmer, of the University of Oslo, known for his work on the aurora polaris, is visiting the University of London.

Dr. Jon Alfred Mjoen, director of the Norwegian Government Laboratory at Oslo and chairman of the Consultive Eugenics Commission of Norway, gave on March 6 an illustrated lecture on "Why Nations Rise and Fall" at the University of California under the auspices of the American Eugenics Society and the University of California Extension Division. Dr. Mjoen plans to spend some time on the Pacific Coast making a special study of race and immigration problems.

Dr. Harlow Shapley, director of the Harvard College Observatory, delivered the annual Sigma Xi lectures at the University of North Carolina on February 13 and 14. The titles of the lectures were "Order Among Star Clusters and Nebulae" and "From Electrons to Galaxies."

The Gehrmann Lectures for 1929–30 at the University of Illinois College of Medicine will be delivered on March 27 and 28 at 4:30 p. m. by Dr. Simon Flexner, director of the Rockefeller Institute of New York City. The titles of the lectures will be, respectively, "The Epidemiology of Poliomyelitis" and "Epidemic and Post Vaccinal Encephalitis and Allied Conditions."

Dr. William H. Park, professor of bacteriology and hygiene at the University and Bellevue Hospital Medical College, New York City, lectured on March 14 before the New York University Chapter of Sigma Xi on "The Etiology and Prevention of Respiratory Diseases."

Dr. K. Lark-Horovitz, professor of physics and director of the physical laboratory at Purdue University, addressed the local chapter of the Sigma Xi on

March 1 on "Recent Progress in the Art of Glassmaking."

PROFESSOR EDWARD L. THORNDIKE, of Teachers College, Columbia University, will be the second lecturer during the current year on the George Slocum Bennett Foundation at Wesleyan University. The subject of the first lecture will be "The Psychology of Learning by Repetition," and of the second "The Psychology of Learning by Rewards and Punishments."

PROFESSOR G. H. PARKER, of Harvard University, addressed the American Academy of Dental Science on March 5 on "Certain Aspects of Evolution and Heredity."

DR. ESMOND R. LONG, professor of pathology in the University of Chicago School of Medicine, will deliver the sixth Harvey Society Lecture at the New York Academy of Medicine, on the evening of March 20. His subject will be "A Chemical View of the Pathogenesis of Tuberculosis."

DR. DONALD C. BARTON, consulting geologist of Houston, Texas, completed on February 28 a series of lectures on geophysical methods for the department of geology of Columbia University.

A. L. KIMBALL, of the General Electric Company, spoke to the students and teachers of the department of physics at Amherst College on February 19. His subject was "Elastic Properties of Matter." Mr. James J. Lamb, technical editor of *Q. S. T.*, the official organ of the American Radio Relay League, spoke recently before a group of Amherst College students interested in radio communication. Through the generosity of an alumnus the department of physics is to be equipped with modern apparatus for work in this field.

THE forty-second annual meeting of the American Physiological Society will be held at the University of Chicago from March 26 to 29, with other societies forming the Federation of American Societies for Experimental Biology.

THE seventy-seventh annual meeting of the American Pharmaceutical Association will be held in Baltimore from May 5 to 10. This includes the meetings of the National Association of Boards of Pharmacy, the American Association of Colleges of Pharmacy, the Conference of Pharmaceutical Association Secretaries and the Conference of Pharmaceutical Law Enforcement Officials.

THE sixty-second annual meeting of the Kansas Academy of Science will be held at the Kansas State Teachers College at Hays on April 18 and 19. Papers will be presented in two general sessions on Friday, April 18, and one on Saturday, April 19. There probably will be a section meeting in chemistry and physics and another in psychology. The presidential address by Dr. W. B. Wilson, of Ottawa University, will be given following the banquet on Friday evening. His address will be on the value of an academy of science to the state. Later in the evening Dr. T. D. A. Cockerell, of the Department of Biology of the University of Colorado, will deliver an address under the joint auspices of the academy and the college on "A Naturalist Around the World." Dr. Cockerell will act as a representative of the American Association for the Advancement of Science. A trip to the Hays Branch Experiment Station of the Kansas State Agricultural College is being planned by the local committee of the academy at Hays.

THE entire colony of 700 to 800 experimental animals of the Food Research Laboratories, Inc., of New York City, was recently destroyed by asphyxiation due to the improper functioning of special gas radiators. Having been informed by experts that the catastrophe must have been precipitated by some human agency, a reward of five thousand dollars has been offered by Dr. Philip B. Hawk, the president of the corporation, for the arrest and conviction of the guilty person or persons. Detectives are actively investigating the matter.

THE residue of the estate of the late Elizabeth R. Stevens, of Swansea, Massachusetts, said to amount to $5,000,000, will be divided among the Union Hospital, Wellesley College, Mount Holyoke College, Massachusetts Institute of Technology, Massachusetts Eye and Ear infirmary and the Joseph Case High School of Swansea.

IT is announced at Swarthmore College that only $175,000 must be raised to complete the endowment fund of $2,000,000. The list of large donations is headed by one of $675,000 from the Rockefeller Foundation, which brought its total contribution to $1,350,000 within a year. Edward S. Harkness, of New York, contributed another $250,000, after having given a similar amount last spring. A conditional promise for a gift of $335,000 was obtained from the Julius Rosenwald fund. Another foundation has given an informal assurance of $150,000. Lessing J. Rosenwald, of Philadelphia, contributed $15,000, which can be used, principal or interest, at the discretion of the president of the college. From an anonymous donor came $400,000 for the endowment of the department of biology in the name of Dr. Edward Martin, and another $200,000 for a building in which it can be housed. This same donor previously had given $300,000 for the same purpose.

Mr. George F. Baker, of New York, who several years ago made a gift of $1,100,000 to Dartmouth College for construction of the Baker Memorial Library, has given an additional $1,000,000 for the maintenance and operation of the library. The library was dedicated in June, 1928, as a memorial to Mr. Baker's uncle, Fisher Ames Baker, a Dartmouth alumnus of the class of 1859.

The vice-chancellor of the University of Cambridge has announced that the Royal Society, in virtue of its reversionary interest in the residue of the estate of the late Mr. E. W. Smithson, holds a sum yielding about £1,200 a year, and that the regulations now published have been adopted by the Royal Society after consultation with the council of the senate in order to give effect to the terms of the bequest. The Regent House will be asked to pass a grace to the effect that Professor Seward, master of Downing; Mr. W. H. Mills, of Jesus College, and Mr. R. H. Fowler, of Trinity College, be appointed members of the committee for the administration of the Smithson Research Fund. The Royal Society will appoint four members of the committee. The committee will devote the income of the fund, or such part of it as may be necessary, to the establishment and support of a fellowship for research in natural science, with a view to the discovery of new laws and principles. It is to be called the Smithson research fellowship.

Industrial and Engineering Chemistry states that Mr. Francis P. Garvan has come to the aid of the American Chemical Society, and has enabled the directors to vote a budget for 1930 which is $95,000 in excess of its normal income, thus enabling the *Journal of the American Chemical Society* to publish promptly all accepted articles, which had accumulated to the extent of some six regular issues, and to meet the normal increase of the year. The foundation will also meet the increased needs of *Chemical Abstracts* and the *Analytical Edition of Industrial and Engineering Chemistry* for the coming year.

Through the generosity of Merck and Company, of Rahway, New Jersey, a fellowship in analytical chemistry with a stipend of $1,000 has been established at Princeton University for the academic year 1930–1931. The purpose of the fellowship grant is to foster fundamental research in the development of new or improved qualitative and quantitative analytical methods.

The University of Pennsylvania has received from Mr. Eldridge R. Johnson, a trustee, $250,000 for the further endowment of the Eldridge R. Johnson Foundation for Research in Medical Physics. Mr. Johnson's gift formed part of a $500,000 contribution which he made in connection with the effort of the university's trustees to meet deficits incurred by the university and to provide it with the nucleus of an adequate endowment fund. His latest gift raises the total endowment of the foundation to $850,000.

The Jordan-Eigenmann collection of fishes recently secured from Indiana University for the California Academy of Sciences by Dr. Evermann has now arrived at San Francisco where it is temporarily stored in the basement of the Steinhart Aquarium of the academy. Dr. Evermann, Mr. Alvin Seale, superintendent of the aquarium, and Mr. H. Walton Clark, assistant curator of fishes in the academy museum, together with several student assistants, spent the entire month of October in packing the collection and loading it in a box car for shipment west. The collection is one of the largest and most valuable in America. It contains more than 220,000 carefully selected specimens representing an unusually large percentage of the known species of North, Middle and South America. The shipment was made in about 100 large earthen jars, 13 large boxes and about 500 large cartons made especially for the purpose. The total weight of the shipment, including containers, was 36,000 pounds. The packing was done under the immediate supervision of Messrs. Seale and Clark and the loading of the car under Mr. Seale's supervision. The fact that the shipment reached its destination without the lose or injury of a single specimen speaks well for the care and excellent judgment shown by Mr. Seale and Mr. Clark. Such a shipment so eminently successful is probably without parallel in this country. The collection is now being opened up and placed on temporary shelving in a fire-proof room where it will be available for study and from which it will be transferred in the near future to permanent quarters especially constructed for the academy's ichthyological collections in the east wing of the academy's museum now under construction. This Jordan-Eigenmann collection, together with the very rich and valuable Jordan collection of about 100,000 specimens at Stanford University, will make this the ichthyological center for the entire Pacific area.

The *Journal* of the American Medical Association reports that the establishment of a department of medical and surgical research is being arranged by the Ohio State University. Creation of the department was authorized by the Board of Trustees as an expansion of the work of the college of medicine. The purpose will be "to coordinate the medical research in medical and surgical fields in the college, to work with the clinical members of the present staff and to inaugurate a program of scientific investigations that should be very fruitful of results." The personnel

will include a professor, an assistant, technician and clerical assistants. According to the dean, the new department "promises to greatly enhance the usefulness of the college of medicine in scientific and clinical medical fields." The college of medicine is the oldest unit of the Ohio State University.

THE New York *Times* writes editorially as follows: "To further the interests and usefulness of science the Association of Scientific Workers was organized in Great Britain two years ago. Small though it be, the association has made its influence felt on both Lords and Commons. Major Arthur Church, its energetic secretary and a doctor of science himself, stood for the House, was elected and promptly proceeded to organize no fewer than seventy of his fellow-members into what is merely the nucleus of a parliamentary science committee through which the association will endeavor to apply science in the service of the empire. Far from being an upstart, the parliamentary science committee, like most things British, has a respectable ancestry. Until 1866 the British Association for the Advancement of Science championed the cause of the physicist, biologist and chemist through a small parliamentary committee and thus succeeded in improving navigation and the weather-forecasting service; determining the conditions under which civil list pensions were to be awarded to scientists; raising the standard of scientific teaching; furthering the exploration of Africa by Livingstone, Speke and Grant, and inducing Tyndall and Huxley to express their opinions on the best method of introducing physical science into the curricula of the public schools. The example thus set may well be considered by Congress and American men of science. No government in the world conducts so much industrial and purely scientific research, through its bureaus, as ours. Yet the scientist plays no conspicuous part in our legislative halls."

DISCUSSION

THE PROPORTIONS OF THE GREAT PYRAMID OF GIZEH

IN a recent most interesting address on "Mathematics before the Greeks,"[1] Professor Archibald incidentally enumerates various "mystical" interpretations of the proportions of the Great Pyramid. This reminded me of an explanation suggested by the photograph which hangs before me in my office.

Whatever the reason for the choice of dimensions, the proportions seem artistically perfect. Is this a delusion due to familiarity or is there a mathematical basis for such a conclusion?

The apparent angle φ between the opposite inclined edges of a pyramid varies, as the spectator travels around the pyramid, from $2 \tan^{-1} (d/h)$ to $2 \tan^{-1} (.707\ d/h)$, where h is the height and d is half the diagonal of the base. Now the dimensions of the Great Pyramid are such that the ratio of the apparent width of the base ($2d \cos \vartheta$) to the height varies from a maximum of 2.222 to a minimum of 1.572. If these values are plotted as a function of the angle ϑ, the average value is exactly 2, which is the value which corresponds to a right triangle. This means that if the pyramid were rotated in front of a distant observer, the apparent angle between the opposite edges at the apex would vary between 96° and 76.3°, but the average value would be the angle 90°. This follows mathematically from the fact that the ratio of h (481 feet) to d (534.4 feet) is exactly the ratio of $\sin \pi/4$ to $\pi/4$, that is 0.900.

Now let us consider the vertical section of the pyramid perpendicular to two faces, the section any architect would draw. According to the Encyclopaedia Britannica, the angle between each face and the base has the following values, for the four pyramids of Medum and Gizeh.

Name	King	Angle
1. Medum	Sneferu	51° 52′
2. Great Pyramid of Gizeh	Khufu	51° 52′
3. Second " " "	Khafra	53° 10′
4. Upper " " "	Menkaura	51° 10′

Why did the architect in each case choose an angle of about 52° instead of 45° or 60°? It is an interesting fact that for a right triangle having a lower angle of 51° 49.6′, the height is the geometric mean between the base and the hypothenuse, that is, the ratio of hypothenuse to height is equal to the ratio of height to base, giving a right triangle with perfect proportions. In the case of the first two pyramids the angle approximates this ideal angle within one part in a thousand. However, the fact that the third and fourth pyramids depart from this angle, one being slightly more and the other slightly less, suggests that the design was not controlled entirely by a mathematical formula, but was subject to modification according to artistic judgment, which, however, oscillated about the value given by the formula.

GORDON S. FULCHER
CORNING GLASS WORKS

[1] SCIENCE, 71: 115, January 31, 1930.

THE NEW MADRID EARTHQUAKE—AN UNPUBLISHED CONTEMPORANEOUS ACCOUNT

I RECENTLY came upon the following record of observations of the New Madrid earthquake in an old

journal in my possession of my great-grandfather, William Brown. The observations were made by him at his home three miles north of Hodgenville, Kentucky, and forty-six miles directly south of Louisville. This location was 225 miles slightly north of east of New Madrid. He has left numerous records in this journal, some of which have been published, that indicate the accuracy of his observations and records. The notes of the earthquake seem worthy of publication because accurate records of it made at the time are few and unexcited ones very rare.

Mount Gilead Kentucky Earthquake on Sunday night Decr. 15th, 2 of the clock at night a severe shock of an earth quake was felt. The motion of shaking continued about 15 minutes. About half an hour after this shock was over another was felt less severe, continued only a minute or two. The next day, Monday morning the 16th, a little after sun rise another shock was felt, the tremor continued a few minutes. Two other slight shocks were felt that morning—the next shock was on Sunday about midday not so violent as the first. The weather for some days before had been dull and cloudy. Again on the night of the 30th instant a shock was felt. Again on Jany (Thursday) 23 1812 at 8 o'clock in the morning another severe shock was felt. The tremor continued for several minutes. When it had stilled another shock was felt which lasted a minute or two. On Monday morning Jany. 27th, a slight shock was felt—on Tuesday evening, 4th Feby 1812 a slight shock was felt. The trembling of the earth continued for several minutes suppd. 6 or 7—and a rumbling noise heard. These are the shocks that we have felt at this place. By report hardly a day passes but the trembling of the Earth is more or less felt. In time of the severest shocks to attempt to walk you feel light head and reel about like a drunken man. Again on the night of Thursday, the 6th Feby. about 4 o'clock A. M. a very severe shock was felt which lasted fully 15 minutes with a rumbling noise like distant thunder and three very distinct reports like cannon was heard at the end of it. Again on Friday night the 7th a smart shock at 8 o'clock then about 11 o'clock another less severe. Frequently you may feel a trembling in the Earth when there is no visible appearance of shaking. It has invariably been cloudy weather about the time of the shocks and rains or snow shortly after. Again on the night 20th Feb. about 9 or 10 o'clock 2 slight shocks were felt the last of which continued its tremor for more than 15 minutes. Again on Saturday night 22d about 10 o'clock another slight shock.[1]

There are not many contemporaneous accounts. Fuller republished in SCIENCE[2] most of Audubon's account in his "Journal." It was written two or three years after the occurrence and is inaccurate; he puts the date a year after it occurred, and the first shock as occurring in the afternoon while he was riding. Bradbury, the British botanist, happened to be at the very center of the disturbance, on the Mississippi River, and describes it carefully in his "Travels in the Interior of America." Bradbury was a trained scientific observer and, as might be expected, his account is the most valuable. In the *American Geologist*,[3] Broadhead brings together most or all of the other early accounts that have been published. Of these, the account of Eliza Bryan, of New Madrid, taken down four and one half years later by Lorenzo Dow, is the only one that is free from excitement and gives a chronological account of the shocks. Brown's record of the repeated shocks agrees closely with those of Bradbury and Bryan and is the only one that is equally temperate and detailed.

Bradbury mentions the previous appearance of a comet in the following words: "One of the men . . . attributed it to the comet that had appeared a few months before, which he described as having two horns."

Brown also refers to this comet in the note next preceding that of the earthquake in his journal as follows:

A comet with a broomy tail appeared about the first week in September 1811 in the northern region of the Heavens. Its course appeared to be coming from the Northeast and making its way to the Southwest. Continued to be visible until about middle of Jany 1812. The last appearance of it was in the So. Western region of the Heavens.

It is evidence of his freedom from superstition that he does not suggest any connection between the comet and the earthquake.

WM. ALLEN PUSEY

BIOLOGICAL NOMENCLATURE

IN the issue of SCIENCE of January 10, Professor Needham renews, without enthusiasm, his proposal of 1910 of a system of numbering species in lieu of naming them. One serious objection to that plan is that it is much easier to remember names than numbers, and easier to associate names with species than to associate numbers with species. In a magazine article or an address to biologists most of them might recognize names of species, but few would recognize numbers. Furthermore, it is much more difficult to avoid mistakes in writing and printing names than in writing or printing numbers. A mistake in a figure makes the whole number wrong. A mistake in spelling a name may leave the meaning perfectly clear. In proof-reading a mistake in a number may be easily overlooked, whereas a misspelled name is likely to be noticed.

[1] From Wm. Brown's "Journal," pp. 19 and 20, in University of Chicago Library.

[2] May 12, 1905, N. S. XXI, No. 541.

[3] Vol. 30, August, 1902.

Professor Needham's suggestion that trinomials be discarded entirely would only make a bad mess worse. Trinomial nomenclature, recognizing very slight differences by name, whether they be biological, geographical or environmental differences, must be relied upon to save the idea of species, based upon more important and constant differences. It is often necessary to discuss such races, and they can be designated intelligibly only by giving them names. To give them binomial names, thus placing them in the same rank as full species, would be biologically less accurate and would also greatly multiply the species which, to use Professor Needham's own phrase, do not "concern the general reader."

However, I am in hearty sympathy with Professor Needham's protest against the multiplication of genera, now rapidly reaching the point where one must "learn a new genus for almost every species." A vast number of genera now recognized would better serve the ends of science if regarded as subgenera. This splitting process is discouraging to students who would like to engage in biological work, and it makes most of the literature of biology usable to only a very few, neither of which results is desirable. If it were necessary to consider all these small groups genera, regardless of how slight the differences by which they are separated, nothing more need be said, but it is not at all necessary.

Genera are not of equal rank and can not be. Division of species into genera, families, etc., is a man-made system, purely for the convenience of men and women. The question as to whether a given group should be considered a genus or a subgenus is purely a matter of individual opinion, in most cases. It no more accurately represents nature to call most of these groups genera than to call them subgenera. A juryman explained that the jury could have agreed except for eleven obstinate men on the jury. Of course the specialist naturally considers his own brain-children more important than any others, but are they? Should he not consider the thousands of naturalists who are not specializing in his particular line? Should he not endeavor to make his writings and addresses intelligible to a large number of people instead of to two or three narrow specialists, and instead of trying to obscure or conceal his ideas from most of his readers and hearers? Using a well-known generic name, followed by a subgeneric name in parentheses, would indicate to both specialist and non-specialists what organism is under discussion, which is the real purpose of nomenclature, and the subgeneric name would sufficiently indicate the slightly differentiated group in which the specialist is interested. Those who believe that "the purpose of language is to conceal thought" from everybody else will continue to multiply genera, while those who use language to make their meaning plain to all who hear or read will relegate many genera to subgeneric rank.

UNIVERSITY OF COLORADO JUNIUS HENDERSON

A NATURAL CAT MUMMY

THE November–December, 1929, issue of *Natural History* prints the following statement:

> In a recent issue of *Palaeobiologia*, Professor Julius Vigh of Budapest describes a natural mummy of a house cat. After death the cadaver of the cat dried out thoroughly without decay and has been preserved for more than ten years.

The writer has in his possession a similar specimen which he has used for the past six years in lectures to his classes in paleontology at Brown University, since it is an illustration of how fossilization may originate through desiccation. The history of the specimen and its state of preservation may interest paleontologists and others.

The cat in its present state came into the writer's possession about 1911 or 1912 while he was a boy in high school at Plainfield, New Jersey. It had been found in a barn, under the following circumstances. The finder, a fellow student of the writer, had disturbed some hay which had long lain in a corner of the building. In so doing he came upon the dried body of the cat lying on its side. How long it had been under the hay there was no means of knowing, but certainly it had been there long enough for complete desiccation of what parts remained at the time of discovery. Turning the carcass over, an opening nearly as large as a tennis ball may be observed on the under (right) side, exposing nearly the entire visceral cavity from which all soft parts have decayed. These, and part of the left hind foot, the tail and most of the fur are missing, but otherwise the specimen is practically complete, even to the dried eyeballs and remnants of whiskers. The stiff, hard, resonant skin is drawn tightly over the bones in all parts, and the ears are dried to thin, parchment-like pockets. When first secured, the cat had a slight odor, but this long since disappeared, and the specimen has been kept for some seventeen or eighteen years without any preservative or particular care. To-day it shows no sign of further deterioration. Evidently, the viscera rotted away soon after death; and, this locus of decomposition having been removed even after the manner of preservation of the Egyptians of old, the rest of the body, partly shut off from the air by its hay covering, "kept" perfectly.

The manner of death may be surmised. There is evidence of mutilation prior to death. The missing tail may have been lost before or since the cat died; that can not be definitely determined. But the left hind foot is crushed, the bones protruding from the

ragged fragments of dried skin, and the toes missing. The mouth gapes open, and the head is twisted sidewise in an unnatural attitude as if the animal died in a paroxysm. It seems probable that the foot was injured in some manner, possibly by being trampled upon by one of the horses kept in the barn where the cat was found. Finding itself wounded, the creature crawled into the hay and expired.

The writer recalls a similar case of a cat injured on a New England farm. This cat lost a foot in the mowing machine and crawled away to die in a small loft over a shed where it was subsequently found. Whatever was the actual fate of the mummified cat we may only guess, but the excellent specimen remains. Although not a true fossil, at least it is akin to the authentic remains, since it graphically demonstrates the preservation of such classic examples as the Moa skin and feathers from New Zealand caves or the ground-sloth skin and hair from the Americas, both fossils formed by desiccation.

BRADFORD WILLARD

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MOUSE OPOSSUM STOWAWAYS ON BANANAS

IT seems worth while to add another note relative to finding the small tropical marsupial Marmosa, known as the mouse opossum, as a banana stowaway.

Previously, Dr. L. A. Adams[1] recorded finding some of these marsupials, and Professor Geo. Wagner and also Mr. E. R. Warren[2] reported others.

A female with litter was brought to our laboratory on June 14, 1929, indirectly from a grocery store, one of an Akron chain store concern. It had been hiding in a bunch of bananas, quite possibly coming from Central America. I could determine the animal to the genus Marmosa, but not to species. This adult female, with total length of 28.5 cm, or 11.2 inches, including the tail which itself was 14.5 cm or 5.7 inches long, was smaller than the measurements given by Anthony for one species *M. isthmica,* and may possibly be the *M. zeledoni* he describes as typical from Central America.[3]

Nearly a dozen young were clinging to the mother, but they were hard to keep count of, unless the mother, who kept well secreted under leaves in a box, was much disturbed. She may have been thus disturbed previous to receiving and again was badly disturbed a week later in attempts to photograph her out in the bright light of the open. She was naturally inactive, secretive, though very much on the alert and seemingly nervous. She would snap viciously with remarkable speed when a hand or instrument was placed within a few inches of her head. The young clung with claws almost anywhere on the fur, but principally ventrally, and occasionally on the tail. A few times one of the young wandered off a few inches. When I approached it closely the mother would grasp it with the claws of one foot and speedily thrust it under her.

It was seemingly impossible to furnish the desired diet or a diet entirely adequate for lactation. The mother ate of bananas regularly, as much as possibly an eighth or a tenth of a banana a day. Following the information previously given that insects were normal food, various insects both dead and live were put near her, but there was no evidence of feeding upon these. Several young died in the early days of the two and a half weeks I had the mother alive in a box. Possibly some young had been abducted, but as I found parts of two bodies in the box it appears certain that the mother ate of her young. No other animals could have entered the box, since it was securely covered with a fine screen. Three young were alive for some days. Then one day only one was left. The next day the mother was gone, undoubtedly escaping after some one had removed her in order to handle her. Later she was found in an open jar of formaldehyde solution. Attempt at feeding the one remaining young with cow's milk was unsuccessful.

It seems of interest to add that the mother made a low, clicking, chirping sound quite uniformly when disturbed.

WALTER C. KRAATZ

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SPECIAL CORRESPONDENCE

A BIOLOGICAL SURVEY OF LAKE ERIE

DURING the summers of 1928 and 1929 an extensive biological survey of Lake Erie was carried out through the cooperation of the U. S. Bureau of Fisheries, Buffalo Society of Natural Sciences, New York State Conservation Department, the departments of game and fish of Pennsylvania, Ohio and of the government of Ontario, and the Health Department of the City of Buffalo. The primary purpose of this survey was an inquiry into the reasons for the decline in the commercial fishery industry in the lake, and included in its scope the study of various biological,

[1] SCIENCE, February 24, 1928.
[2] SCIENCE, April 20, 1928.
[3] Anthony, "Fieldbook of North American Mammals," p. 7.

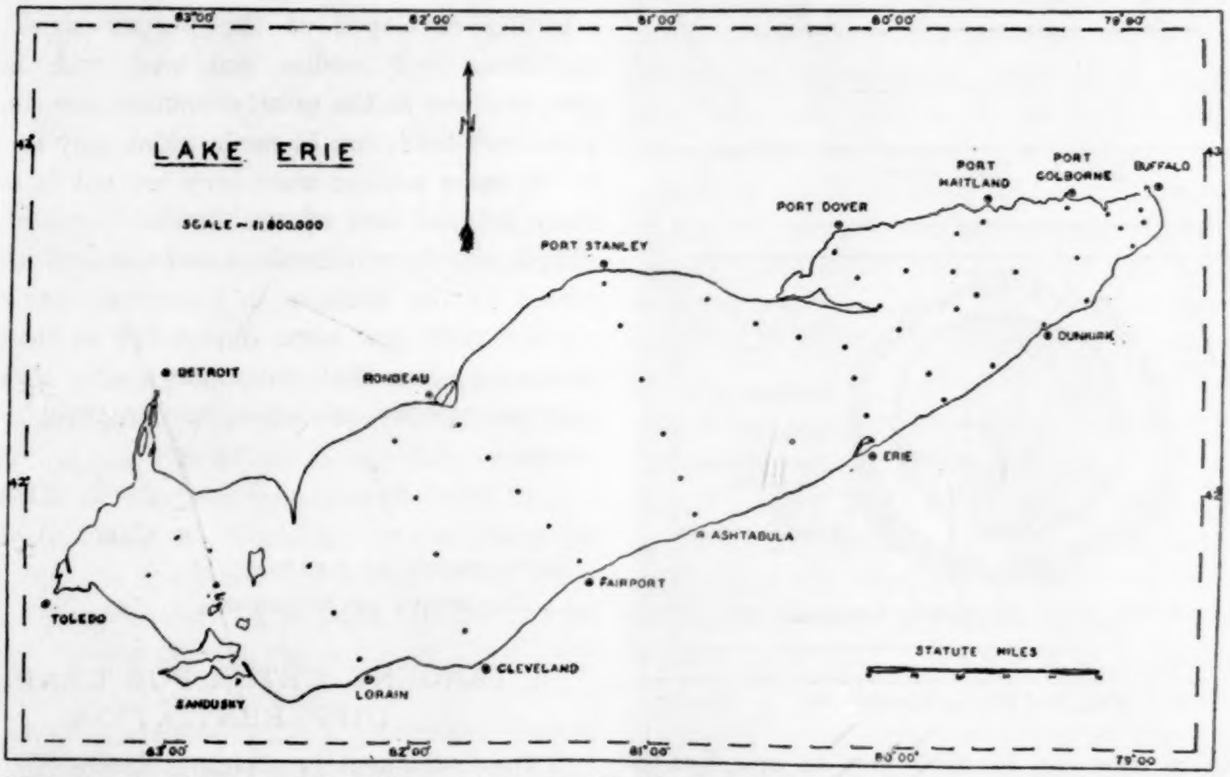
chemical and physical factors which bear an important relationship to the production of fish. For the successful operation of the program the steamer *Shearwater* was given by the U. S. Bureau of Fisheries, the maintenance of the vessel and salaries of the crew and several scientists generously financed by New York State and one or more specialists contributed by each of the other cooperating institutions.

Operations which were confined to the eastern portion of the lake during the preliminary survey in the season of 1928 were extended in the summer of 1929 to the entire lake. During the period from May to September in 1929 observations were made every month at a large number of selected stations which are shown on the map. These observations embraced a variety of special studies such as the spawning and growth of young fish, the production of phyto- and zooplankton, the physical hydrography, the chemistry as an index to normal lake conditions and extent of pollution, the lake sediments, etc.

The staff of investigators consisted of the following:

Charles J. Fish, Buffalo Museum of Science, director.
Charles K. Green, U. S. Coast and Geodetic Survey, hydrographer.
Marie P. Fish, Buffalo Museum of Science, ichthyologist.
Charles B. Wilson, Westfield Normal School, macroplanktonologist.
Paul R. Burkholder, Buffalo Museum of Science, microplanktonologist.
Reginald H. Pegrum, University of Buffalo, geologist.
Casimir J. Munter, Ohio State University, chemist.
Arthur H. Louden, Queens College, scientific assistant.

"A Preliminary Report on the Cooperative Survey of Lake Erie" covering the results obtained in the season of 1928 has been published as a *Bulletin* of the Buffalo Society of Natural Sciences. This report includes a discussion of the program and itinerary, topography, hydrography, bacteriology, chemistry, microplankton, macroplankton and ichthyology. A complete report upon the various phases of the investigation together with summary and conclusions is now in preparation.



Map showing location of stations visited monthly by the U. S. *F. S. Shearwater*, summer of 1929

PAUL R. BURKHOLDER

BUFFALO MUSEUM OF SCIENCE

SCIENTIFIC APPARATUS AND LABORATORY METHODS

DISPLAYING AND FILING MICROSCOPIC PREPARATIONS

THE method here described has been found most satisfactory after many years of experience with extensive series of demonstration material used in connection with courses in microscopic anatomy. A sketch of that portion of the preparation to be shown, with the necessary legends and explanations, is placed on a 5 x 8 inch cardboard having a drawing surface (Crescent mat board is very satisfactory).

This is covered with a 5 x 8 inch sheet of transparent celluloid (such as Eastman Kodaloid No. 3) and the two are bound together with 1-inch-wide black adhesive tape, such as is used for fastening shields on the inside of automobile windows (*e.g.,* Durwood 3A tape), as shown in the accompanying figure, front view. A little more than half of the width of the tape is folded on to the back (see Fig. 1). Ordinary

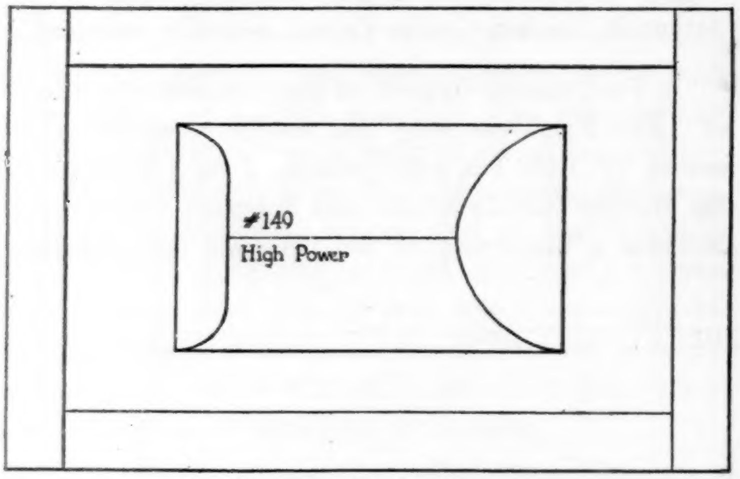


Fig. 1. Back view.

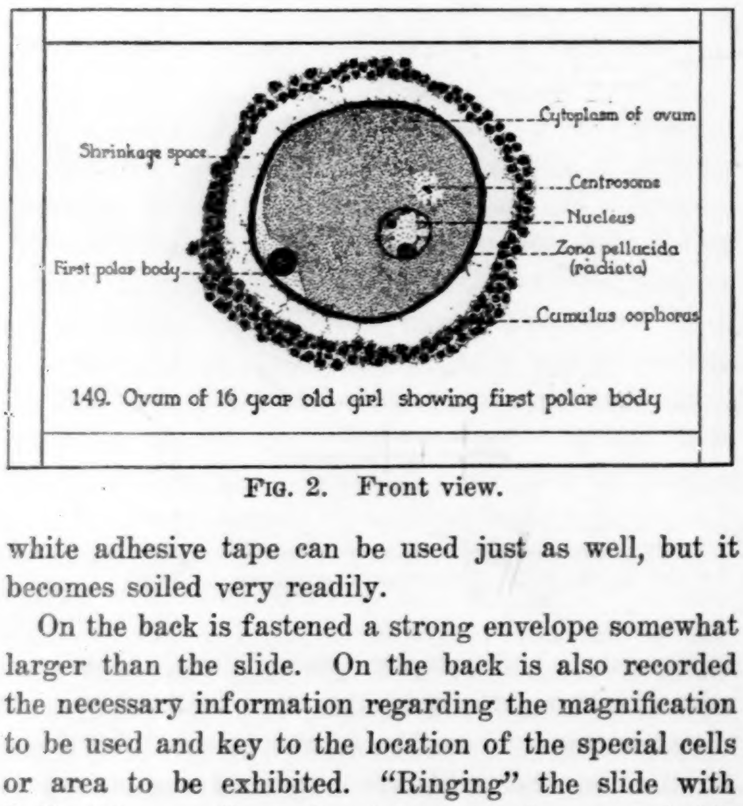


Fig. 2. Front view.

white adhesive tape can be used just as well, but it becomes soiled very readily.

On the back is fastened a strong envelope somewhat larger than the slide. On the back is also recorded the necessary information regarding the magnification to be used and key to the location of the special cells or area to be exhibited. "Ringing" the slide with India ink or a diamond point may make some of this information unnecessary. When filed away, the slide is kept in the envelope of the corresponding card. The card and slide should bear the same number, and the number on the slide should be placed so that when the number is right-side-up the slide is properly oriented on the microscope. When in use the card is placed beside the microscope. The transparent cover prevents the sketch from being marred.

If it is desired to write the explanations with the typewriter, a thinner drawing paper is used which is pliable enough to be handled by the typewriter. The sheet containing the sketch is covered with the sheet of celluloid and backed by a 5 x 8 inch piece of stiff mounting board and the three bound together with the tape.

A photograph, with the necessary indicators and explanations put in by hand, may take the place of a sketch. A very light print on a mat surface may be used for the general outline and special areas, or particular cells sharpened up and focal depth increased by retouching with diluted India ink. Explanatory cards thus mounted may be prepared to accompany models and gross specimens that are used regularly for demonstration purposes.

These cards are neat, durable and inexpensive. They make for simplicity in filing. Slides of any size, up to sections of the entire hemisphere of the adult human brain, may be accommodated by merely selecting envelopes of the proper sizes. If gross specimens and models are used with microscopic preparations in the same demonstration, uniform explanatory cards can be made which may be filed away in the same cabinet when they are not in use. Carefully selected sets of well-labeled demonstrations to supplement loan collections and material actually dissected by the students in biological courses are becoming more and more imperative as the enrolment increases, since they make it possible to reduce the relative number of laboratory instructors in some cases.

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A TANGENT METER FOR GRAPHICAL DIFFERENTIATION

This instrument is a simple device for the direct measurement of the tangent to a curve at any point. The derivative curve may then be rapidly and easily obtained by plotting the tangents. Since the measurements may be made as near each other as is desired, maxima, minima and points of inflection may be found without reference to the rest of the curve, as would be required by numerical methods such as finite differences.

Numerous applications will appear to those who do graphical work involving rates of change, especially in case the equation of the curve to be differentiated is unknown. The instrument may also serve as an aid in curve fitting. The biologist may use the instrument in determining the rate of growth of an organism, at any time, from the plot of the growth curve. Objective analysis of the graph of any equilibrium of a living system becomes possible directly without other information than the original graph of the ob-

servations. The saving of the investigator's time is apparent because it is possible subsequently to measure rates at intermediate intervals without repeating laborious numerical computations.

The instrument consists of a base cut out at the center to receive a flanged rotatable disk. The center disk is held in place by being bolted to the indicator, Fig. 1. The exact center of this disk is marked by

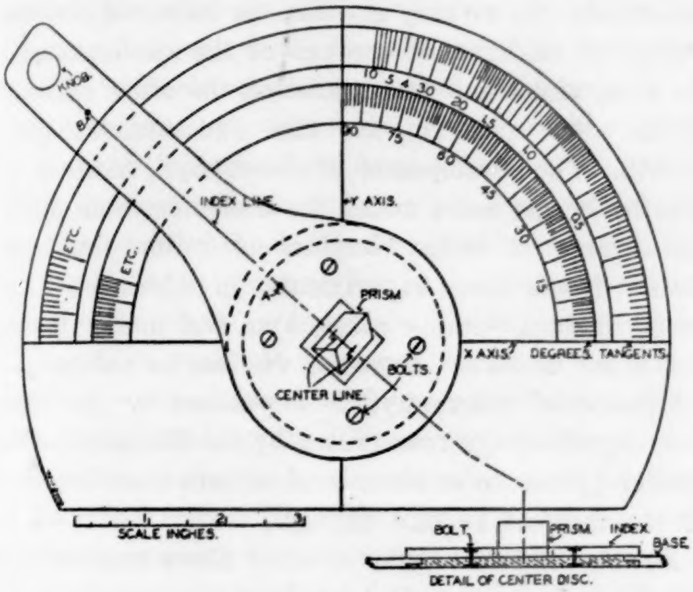

Fig. 1

crossed center lines on the under side, and an isosceles (or equilateral) triangular prism is placed odd face down on the upper side of the center disk in such a way that the lateral edge opposite the odd face is directly over the center. The main axis of the prism is perpendicular to the index line drawn on the under side of the indicator arm. A suitable opening for the prism should be cut through the indicator. All parts are made of transparent viscoloid.

The base is graduated with a protractor degree scale and with a tangent scale. Tangents to unity (45°) may be read directly to 2 parts in 100 and may readily be estimated to 1 part in 100. Above unity the magnitude of the tangents increases rapidly and the accuracy of the reading is proportionally less. The loss in accuracy does not appear greatly in the practical use of the instrument since many curves do not slope more than 60° and with greater slope the tangent may be obtained from the related function measured after the instrument has been rotated 90°. Increased accuracy may be obtained by increase in the size of the instrument and the number of divisions on the scales and by the use of a more transparent glass prism. When the slope of the curve is negative the tangent is read on the left-hand scale. (This scale is not completely illustrated in Fig. 1 because it is a mirror image of the scale on the right-hand side of the instrument.) The reading on the tangent scale is correct when the units of the abscissa and ordinate are equal; in other cases the readings must be multiplied by an appropriate factor.

To use the tangent meter place the crossed center lines directly over the point on the curve where the slope is to be measured, make the x- or the y-axis of the instrument parallel to the same axis of the curve by rotating the instrument and then turn the indicator arm until the image of the curve is seen through the prism to be a continuous line. Then the tangent to the curve at the point selected may be read on the tangent scale, or the angle that the tangent makes with the x-axis may be read on the protractor scale. When looking at the cross of the center lines from above the prism it is seen as two crosses, one at each side of the prism, due to the refraction of the prism (*cf.* Fig. 1). The tangent may be drawn to the curve by extending the line connecting two points made by pushing a pin through the holes A and B on the index line. For drawing tangents or normals to curves, where the operation is to be repeatedly performed, a convenient form of the instrument may be made by mounting a prism at the proper angle on a projecting section at the center of a straight edge.

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Percy M. Roope
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SPECIAL ARTICLES

THE GERMINATION OF SEEDS, GROWTH OF PLANTS AND DEVELOPMENT OF CHLOROPHYLL AS INFLUENCED BY SELECTIVE SOLAR IRRADIATION

The energy in sunlight ranges from the infra-red (or heat) rays, through the visible from red to violet and on into the ultra-violet—the short rays of sunshine so necessary to prevent rickets. Are each of these regions of solar energy equally necessary as aids to germination, development, growth and maintenance of existence, or do quality (wave-length) and quantity (intensity) of energy enter as important factors? Are certain wave-lengths and intensities of radiant energy used by plants for one purpose, while other regions and intensities of energy perform a distinctly different function and service? Do certain wave-lengths of solar radiation promote growth, while other regions of solar energy retard it? Is the development of chlorophyll chiefly dependent on the infra-red, visible or ultra-violet rays?

We have endeavored to answer these and similar questions by making physical measurements on the quality (wave-length) and quantity (intensity) of the radiant energy used, the amounts of chlorophyll developed and so forth and by conducting biological experiments on the number of germinations, heights and weights of plants and areas of leaves.

Effects produced under quartz-containing glass, ordinary window glass, amber and blue glass filters.—Quartz-containing glass transmits the whole of the visible portion and a very considerable part of the ultra-violet region of sunlight; ordinary window glass deletes the shorter ultra-violet wave-lengths in large part; amber glass transmits only the longer wave-lengths while blue glass transmits only the shorter visible and longer ultra-violet wave-lengths of incident radiant energy.

Employing Pittsburgh amber No. 48, Pittsburgh blue No. 56, vitaglass (quartz-containing glass) and ordinary window glass, our experiments have shown: (1) In general, the number of germinations is the greatest under vitaglass or ordinary window glass, comparable under the blue filter and least under the amber glass. (2) The average height of stalks increases as we pass from the plants grown under ordinary window glass to vitaglass, to the blue filter and finally to the amber glass. (3) The areas of the leaves are the greatest under vitaglass, less under ordinary window glass, still less under the blue filter and least under amber glass. (4) The weights of plants (stalks and leaves) as grown under the four filters are in the order: vitaglass, amber, blue and ordinary window glass. (5) The lengths and weights of the roots are of the same order of magnitude and arranged in the same sequence as the lengths of stalks and weights of plants. (6) The development of chlorophyll for each gram of plant (not dried) is greatest under vitaglass and decreases in the sequence of ordinary window glass, blue and amber filters.

A comparison of these biological results with the data regarding the percentages of various types of solar radiation transmitted to the plants indicates that the growth is greater under either the longer or shorter wave-lengths of sunlight than it is under the full complement (practically) of sunlight. The infra-red transmissions of the four filters are comparable, therefore this region of solar radiation does not appear to be the controlling factor. Furthermore, the growth under amber or blue filters, which transmit from 30 to 40 per cent. only of the visible portion of sunlight, is greater than under vitaglass or ordinary window glass which transmit about 90 per cent. of the incident visible light. The growth is greater, therefore, under a portion of solar radiation than it is under the full complement of sunlight. A spectrophotometric study of the amber and blue filters shows that there is a relatively small transmission of energy in the green region of the spectrum. The inference (which is substantiated quite definitely by the experiments under the group of seven Corning glass filters) may be drawn that the green region of the solar spectrum, which is the region of maximal energy of sunlight, is inhibitory in character so far as growth is concerned. Or we may say that the infra-red and red regions of sunlight, at one end of the spectrum, and the blue, violet and ultra-violet at the other extreme of the solar spectrum, are vital and stimulating to growth. The development of chlorophyll, however, is practically the same under the amber or blue filters but is greatest under vitaglass or ordinary window glass. From these experiments, in which we have used vitaglass, window glass, blue and amber filters, it can not be stated, however, whether or not the development of chlorophyll is dependent on the total quantity of energy transmitted by the filters or on the quality (presence or absence of certain wave-lengths) of the incident radiant energy.

Effects produced under spectral filters transmitting chiefly one quality only of radiant energy.—In order to limit more narrowly the quality and quantity of solar radiation incident on any group of seeds or plants we have used a set of special filters[2] which transmit only ultra-violet, violet, blue, green, yellow, red and infra-red rays respectively.

Our results indicate that: (1) The number of germinations is greatest under the infra-red and ultra-violet portions of sunlight and least under the green region. (2) The average height of stalks is greatest in the infra-red and red regions at the one extremity of the solar spectrum and in the violet and ultra-violet portions at the other extremity of the spectrum, and least under the green and heat-absorbing filters. (3) The average weight of plant follows the same sequence as stated with reference to the average height of stalks. (4) The development of chlorophyll is greatest under the green portion of the spectrum and least under the infra-red and ultra-violet radiations.

A comparison of data relative to the quality and quantity of incident energy with the biological effects observed shows that a proportionately small percentage of ultra-violet light (since the ultra-violet content of sunlight is about 10 per cent. only, the visible 15 per cent. and the infra-red 75 per cent.) is as efficacious as the infra-red rays, if not more so, in stimulating and promoting germination and growth.

These observations are substantiated further by the results obtained by Sheard and Johnson on the

[2] Corning Glass Company 586 A, 586 A.W., 585, 584 J, 34 Y, 24, 554 FF and 392 H.

changes in electrical potentials and currents produced in plants by various types of radiant energy. In their experiments it was found that marked changes in potential differences (voltage) were produced by ultra-violet and infra-red radiations and that the electric currents obtained in leaves, when an external but constant electromotive force was impressed, were increased by both these types of radiant energy. Furthermore, these changes in potential differences between the base and the tip of leaves were found to be associated very definitely with the phenomenon of growth. No changes in potential differences or in electric currents were produced by the visible portions of sunlight or various artificial sources of radiation.

The development of chlorophyll is dependent chiefly on the quality of the incident radiant energy, namely, the energy in the green region of the visible spectrum. Little chlorophyll is found in plants grown under filters which transmit infra-red or ultra-violet rays only. A comparison of the energy of the incident light transmitted by these filters and measured with thermopiles shows that a transmission of 5 per cent. of the green region (through a green filter) produces a greater amount of chlorophyll for each gram of plant than is produced by a transmission of 40 per cent. of energy in the yellow or red regions of solar radiation obtained through yellow and red filters.

CONCLUSIONS

(1) The ultra-violet and infra-red portions of sunlight are stimulating to germination and enhance growth and development.

(2) The green portion of the solar spectrum, which is its region of maximal energy, is inhibitory to the processes of germination and growth.

(3) The development of chlorophyll is enhanced under the yellowish-green, green and greenish-blue regions of the spectrum.

(4) The least development of chlorophyll occurs under the ultra-violet and infra-red portions of the spectrum.

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SOME PRACTICAL RESULTS OF AN X-RAY ANALYSIS OF COTTON FIBERS

WHILE it has been known for some time that cotton fibers yield a typical cellulose X-ray diffraction pattern, comparatively little work has been done with this material. The explanation of this lies in the fact that in ramie fibers, for example, there is a much more perfect orientation of the colloidal micelles parallel to the fiber axis than is true in cotton, which appears to have a spiral arrangement. Ramie fibers have, therefore, been practically exclusively used in the brilliant X-ray work which has led to a final analysis of the crystalline part of cellulose. It is now definitely known that cellulose belongs to the monoclinic system and that the unit cell dimensions derived from X-ray patterns are: $a = 8.3$, $b = 7.9$, $c = 10.3$ A.U. The last named is the identity period along the fiber axis, with a monoclinic angle $\beta = 84°$. This small unit cell contains four $C_6H_{10}O_5$ groups. It has been further demonstrated that cellulose is built from long primary valence chains of the dehydrated glucose molecules and that a bundle of these long chains constitutes the colloid micelle or crystal grain. The measurement of the breadth of the X-ray diffraction interferences has proved that in various samples the length of the micelles, which is the same as the length of the primary valence chains, lies between 150 and 500 A.U., and that the cross-section dimension of the micelle, which is determined by the number of chains in a bundle, lies between 20 and 50 A.U.

It is this complete structure of cellulose which enables explanation of the physical and chemical properties of cellulose fibers. Up to the present time all the X-ray work has been devoted to fundamental studies of cellulose and practically nothing has been done in the practical sense of following growth or in classifying fibers of a particular kind. In the X-ray laboratory of the University of Illinois extensive independent and cooperative studies are in progress on wood and on cotton fibers. The first results in comparative studies of cotton fibers have been so promising and have so far exceeded the expectations that it has seemed wise to report in a preliminary note these findings on structural changes during growth and on classification of mature fibers.

A series of developmental stages of the fibers of *Gossypium hirsutum* representing growth intervals of eighteen, twenty-one, thirty-five and fifty days respectively have been studied thus far, by means of the diffraction method, utilizing the copper Kα radiation, the pinhold method and a bundle of parallel fibers as the specimen. The eighteen- and twenty-one-day samples represent the period of elongation in fiber growth. The thirty-five-day sample represents the early stages of wall thickening and the fifty-day sample the mature fiber at the close of its period of wall formation. The diffraction patterns for the four samples show a remarkable progression. In all cases the patterns indicate a crystalline condition which, however, is progressively more perfect with age. The eighteen-day sample pattern is distinguished by very broad and continuous rings indicating random orien-

tation. The principal diffraction ring has a diameter of 4.05 cm. There is no evidence whatsoever of true fibering. The twenty-one-day sample pattern also shows continuous diffraction rings but these are sharper, indicating larger micellar size, that is, longer chains, and the diameter of the principal diffraction ring is 4.25 cm. The thirty-five-day sample pattern shows for the first time definite evidences of preferred orientation as indicated by greater intensity of the diffraction rings on the equator as compared with the poles of the pattern. The fibering, however, is still imperfect. The diameter of the principal diffraction ring is 4.50 cm. Finally, in the mature fifty-day fiber the pattern indicates the maximum degree of preferred orientation, the sharpest and narrowest diffraction maxima, indicating the final size of the micelles and a diameter of the principal diffraction ring of 4.60 cm. There has been thus a progression in these samples in fibering, in micellar size indicated by diffraction breadth and in the actual crystal unit cell dimensions as indicated by the interference ring diameters. The dimensions are largest for the youngest sample. This seems to indicate, therefore, a condition of intra-micellar swelling or of the fact that the primary valence chains are not oriented within the colloidal particle in a perfectly parallel fashion. It may also mean that the crystalline substance is not yet true cellulose. As the sample ages the diffraction ring increases in diameter, which means that the unit cell dimensions decrease until in the mature fiber the dimensions for ordinary cellulose are reached. It is evident that preferred orientation occurs some time between the twenty-first and thirty-fifth day, probably quite sharply. Further tests are now being made with samples showing finer gradation in growth.

Another series of samples of mature cotton fibers showing markedly different physical properties has been subjected to X-ray analysis and here again the diffraction patterns are equally striking in their differences. The samples consisted of a cotton of high quality, one whose fiber quality had apparently been lowered by adverse developmental conditions and a third which represented an inferior variety. In all three cases the diffraction rings have exactly the same measurements corresponding to true cellulose. The differences lie, first, in the degree of preferred orientation, and secondly, in the sharpness of the interference maxima. There is a marked difference in the degree of fibering which is maximum in the case of the first sample and minimum in the third. For example, the cords of the arcs on the diffraction rings produced by fibering have the following lengths: first, 2.8 cm; second, 3.25 cm; third, 3.8 cm. This gradation is exactly the same as that displayed by the qualitative differentiation. Furthermore, an examination of the sharpness of interferences indicates that the chain lengths in the colloidal micelles are greatest in the first sample and least in the third. Therefore, satisfactory physical properties are unquestionably connected with colloidal size greater than a critical value and in the best possible arrangement of these micelles with respect to the fiber axis itself. While these samples represent perhaps extreme conditions it seems very probable that it will be possible to classify cotton within much narrower limits and that the X-ray method will, therefore, prove an indispensable new tool both for specification and research in the cotton industry. A continuation of these studies in a quantitative manner is in progress.

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BOOKS RECEIVED

DARROW, FLOYD L. *The New World of Physical Discovery.* Pp. 371. 14 illustrations. Bobbs-Merrill. $3.50.

DAY, ALLAN R. *Inorganic Qualitative Chemical Analysis.* Pp. ix + 197. 15 tables. Chemical Publishing Company. $2.75.

DE BEER, G. R. *Embryology and Evolution.* Pp. viii + 116. Illustrated. Oxford University Press. $2.00.

DENSMORE, FRANCES. *Pawnee Music.* Pp. xviii + 129. 8 plates. Songs. Smithsonian Institution.

FLINT, H. T. *Wave Mechanics.* Pp. ix + 117. 19 figures. Dutton. $1.25.

GIBBS, R. W. M. *The Adjustment of Errors in Practical Science.* Pp. 112. 43 figures. Oxford University Press. $1.75.

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KAY, GEORGE F., and EARL T. APFEL. *The Pre-Illinoian Pleistocene Geology of Iowa.* Pp. 304. 66 illustrations. Iowa Geological Survey. Vol. XXXIV.

KLIGLER, ISRAEL J. *The Epidemiology and Control of Malaria in Palestine.* Pp. xv + 240. 32 figures. 19 charts. 22 maps. University of Chicago Press. $5.00.

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UNITED STATES NAVAL OBSERVATORY, *Publications of.* Second series. Volume XII. Pp. ix + 592. 11 plates. 23 tables. United States Government Printing Office.

VON DER OSTEN, H. H., and ERICH F. SCHMIDT. *The Alishar Hüyük Season of 1927.* Part 1. Pp. xxii + 284. 251 illustrations. 5 plates in color. 22 maps. 2 tables. University of Chicago Press. $8.00.